(I) Salt of W.A + S.B

eg:- CH_3COONa (SALT) ← Complete Neutralization: $CH_3COOH + NaOH$

let conc. of Salt is c mol/L

$CH_3COONa \rightarrow CH_3COO^- + Na^+$
(Strong electrolyte) $c - c = 0$; c ; c

$Na^+ + H_2O \rightarrow$ ✗

$CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + \bar{O}H$ ($H^+\bar{O}H$)
(Weak electrolyte, Weak electrolyte)

(AH) Anionic Hydrolysis
$[OH^-] > [H^+]$
Soln becomes Basic
$pH > 7$

It is Combination of 2 Rxn:

$CH_3COO^- + H^+ \rightleftharpoons CH_3COOH$; $K_{eq} = \frac{1}{K_a}$

$H_2O \rightleftharpoons H^+ + OH^-$; $K_{eq} = K_w$

$CH_3COO^-_{(aq)} + H_2O(l) \rightleftharpoons CH_3COOH_{(aq)} + OH^-_{(aq)}$; $K_{eq} = K_h = \frac{K_w}{K_a}$ (K_h → Hydrolysis Const.)

$CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$; $K_{eq} = K_a$

$$CH_3COO^-_{(aq)} + H_2O(l) \rightleftharpoons CH_3COOH(aq) + \bar{O}H(aq)$$

	CH_3COO^-	H_2O	CH_3COOH	OH^-
t=0	c	–	–	–
at eqm	c(1−h) = c−ch	–	ch	ch

h → degree of hydrolysis of Anion.

$$K_{eq} = K_h = \frac{[CH_3COOH][OH^-]}{[CH_3COO^-]}$$

$$K_h = \frac{ch \times ch}{c(1-h)} = ch^2$$

mostly $h << 1$ → $1 - h = 1$

$$h = \sqrt{\frac{K_h}{c}} = \sqrt{\frac{K_w}{K_a \times c}}$$

$$[OH^-] = ch = \sqrt{c \cdot \frac{K_w}{K_a}}$$

$$-\log[OH^-] = -\log\left(c \cdot \frac{K_w}{K_a}\right)^{1/2}$$

$K_w = 10^{-14}$
$pK_w = 14$

$$pOH = \frac{1}{2}\left[-\log c - \log K_w - (-\log K_a)\right]$$
$$= \frac{1}{2}\left[-\log c + pK_w - pK_a\right]$$
$$pOH = \frac{1}{2}\left[-\log c + 14 - pK_a\right]$$

$$pH = 14 - pOH = 14 - \left(\frac{1}{2}[-\log c + 14 - pK_a]\right)$$
$$= 14 + \frac{1}{2}\log c - 7 + \frac{1}{2}pK_a$$
$$\boxed{pH = 7 + \frac{1}{2}[pK_a + \log c]}$$

Shortcut

CH_3COONa ⇒ Salt of WA + SB ($WA \rightarrow K_a$)

⇒ $K_h = \frac{K_w}{K_a}$

⇒ $h = \sqrt{\frac{K_h}{c}}$

⇒ AH ✓ $pH > 7$ $pH = 7 + \frac{1}{2}[pK_a + \log c]$ (c → Conc. of Anion of Salt)

(II) Salt of Weak Base + Strong Acid

(NH_4OH , HCl) Weak Base → K_b

eg:- NH_4Cl, $(NH_4)_2SO_4$, NH_4NO_3, NH_4I

$NH_4^+ + H_2O \rightleftharpoons NH_4OH + H^+$

- Cationic Hydrolysis
- $[H^+] > [OH^-]$
- Acidic $pH < 7$
- $pH = 7 - \frac{1}{2}[pK_b + \log c]$ (c → Conc. of Cation of Salt being Hydrolysed)
- $h = \sqrt{\frac{K_h}{c}}$ • $K_h = \frac{K_w}{K_b}$

(III) Salt of S.A + S.B

No Hydrolysis
$[H^+] = [OH^-] = 10^{-7} M$ → due to only H_2O
$pH = 7 = pOH$

eg: NaCl, KCl, Na_2SO_4, KI, $CaCl_2$ etc.

(IV) Salt of W.A + W.B

($W.A \rightarrow K_a$, $W.B \rightarrow K_b$)

eg: CH_3COONH_4 ⇒ Conc = c
NH_4F, NH_4CN, $(NH_4)_2CO_3$, NH_4NO_2

• CH ✓ AH ✓

Equatn: $1NH_4^+ + 1CH_3COO^- + H_2O(l) \rightleftharpoons NH_4OH + CH_3COOH$ (K_w, K_b, K_a)

	NH_4^+	CH_3COO^-	H_2O	NH_4OH	CH_3COOH
t=0	c	c	–		
at eqm	c−ch ≈ c	c−ch ≈ c	–	ch	ch

$$K_h = \frac{ch \times ch}{c \times c} = h^2$$

- $\boxed{h = \sqrt{K_h}}$
- $K_h = \frac{K_w}{K_a \times K_b}$
- $\boxed{pH = 7 + \frac{1}{2}[pK_a - pK_b]}$ → independent of Conc.

$pK_a > pK_b$; $pH > 7$ Basic
$pK_a < pK_b$; $pH < 7$, Acidic

Q→ $10^{-2}M$ $CH_3COONa(aq)$
$K_a(CH_3COOH) = 1.8 \times 10^{-5}$ → $pK_a = 4.774$
a) pH = ?
b) h = ?
c) K_h = ?

Soln:- AH ✓ pH > 7
$pH = 7 + \frac{1}{2}[pK_a + \log c]$
$= 7 + \frac{1}{2}[4.774 + \log 10^{-2}]$
$= 7 + \frac{1}{2}[4.774 - 2]$

$h = \sqrt{\frac{K_w}{K_a \times c}}$; $K_h = \frac{K_w}{K_a}$

Q→ $10^{-2}M$ $(CH_3COO)_2Ca$ ← $Ca(OH)_2$ (S.B) + CH_3COOH (W.A)
$K_a(CH_3COOH) = 1.8 \times 10^{-5}$ → $pK_a = 5 - \log(1.8) = 4.774$
pH = ?

Soln AH ✓ ; pH > 7
$[CH_3COO^-] = 2 \times 10^{-2} M = c$
$pH = 7 + \frac{1}{2}[pK_a + \log c]$
$= 7 + \frac{1}{2}[4.774 + \log(2 \times 10^{-2})]$

Q→ 100ml, 0.1M NH_4OH + 50ml, 0.2M HCl
($K_b = 10^{-6}$)
pH = ?

Soln

	NH_4OH	+ HCl →	$NH_4Cl(aq)$	+ $H_2O(l)$
millimoles =	100×0.1 = 10	50×0.2 = 10	–	–
	−10	−10	+10	–
	0	0	+10 mmoles	

(NH_4Cl → Salt of W.B + S.A)

$[NH_4Cl] = \frac{10}{150} M$
$[NH_4^+] = \frac{1}{15} M = c$

Container has salt & H_2O ; so it is Question of Salt Hydrolysis

Cationic Hydrolysis ✓ Acidic $\boxed{pH = 7 - \frac{1}{2}[pK_b + \log c]}$ $= 7 - \frac{1}{2}\left[6 + \log\left(\frac{1}{5 \times 3}\right)\right] = 7 - \frac{1}{2}[6 - 0.7 - 0.47]$

Note:- Salt Soln of Di or tri basic Weak Acid having atleast one H^+

Q→ pH of 0.1M $NaHCO_3(aq)$?
$K_{a_1} = 10^{-7}$
$K_{a_2} = 10^{-12}$
→ H_2CO_3

Soln $pH = \frac{1}{2}[pK_{a_1} + pK_{a_2}]$

Q→ 0.01M $Na_2HPO_4(aq)$
pH = ?
$K_{a_1} = 10^{-5}$
$K_{a_2} = 10^{-8}$
$K_{a_3} = 10^{-14}$
→ for H_3PO_4

Soln $\boxed{pH = \frac{1}{2}[pK_{a_2} + pK_{a_3}]}$

$H_3PO_4 \xrightarrow{K_{a_1}} NaH_2PO_4 \xrightarrow{K_{a_2}} Na_2HPO_4 \xrightarrow{K_{a_3}} Na_3PO_4$

NaH_2PO_4: $pH = \frac{1}{2}[pK_{a_1} + pK_{a_2}]$; Na_2HPO_4: $pH = \frac{1}{2}[pK_{a_2} + pK_{a_3}]$

Solve Q→12, Pg-138

Step 2 → 1 to 32, 33, 34, 36, 37, 38, 50, 51, 52, 53, 54, 62, 63, 65, 66, 67, 68, 69, 70, 73, 75, 76, 77, 79, 83, 90, 91, 92, 93, **94 to 132